Second Semester Examination
2018/2019 Academic Session

June 2019

EEK260 – (Electrical Machines)
(Mesin Elektrik)

Duration : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of NINE (9) pages of printed before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEMBILAN (9) muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions: This question paper consists of **FIVE (5)** questions. Answer **ALL** questions. All questions carry the same marks.

[***Arahan:*** *Kertas soalan ini mengandungi **LIMA (5)** soalan. Jawab **SEMUA** soalan. Semua soalan membawa jumlah markah yang sama.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

1. A ferromagnetic core is shown in Figure 1. The depth of the core is 10 cm. The other dimensions of the core are shown in the figure. The relative permeability of the core is 1000. Assume that fringing in the air gap increases the effective cross-sectional area of the air gap by 5 percent and the current in the coil is 1.0 A.

   Sebuah teras feromagnetik ditunjukkan di dalam Rajah 1. Tebal teras tersebut ialah 10 cm. Ukuran lain bagi teras tersebut ditunjukan di dalam rajah. Kebolehtelapan nisbi μ_r ialah 1000. Andaikan pinggiran di dalam ruang udara meningkatkan kawasan keratan rentas terkesan bagi jurang udara sebanyak 5 peratus dan arus mengalir di dalam gegelung ialah 1.0 A.

   (i) Draw the equivalent magnetic circuit of the ferromagnetic core as shown in Figure 1.

   Lukis litar magnetik setara bagi teras feromagnet yang ditunjukkan di dalam Rajah 1.

   (10 marks/*markah*)

   (ii) Find the value of each reluctance and total reluctance.

   Cari nilai bagi setiap keengganan dan jumlah keengganan.

   (60 marks/*markah*)

   (iii) Calculate the flux generated in the core.

   Kira fluk terhasil dalam teras tersebut.

   (10 marks/*markah*)

   (iv) Determine the flux density of the air gap

   Tentukan ketumpatan fluk yang terhasil pada jurang udara.

   (10 markah/marks)

(v) Calculate current required to produce a flux density of 0.5 T in the air gap.

Kira arus yang diperlukan untuk menghasilkan ketumpatan fluk 0.5 T dalam jurang udara.

(10 marks/*markah*)

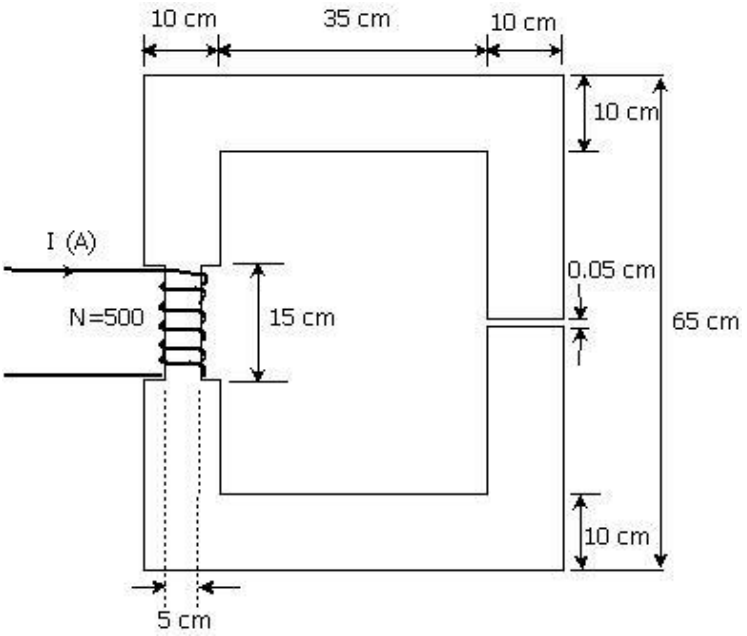

Figure 1: Ferromagnetic core
Rajah 1: Teras Feromagnet

2. Three 20-kVA 24,000/415-V distribution transformers are connected in Δ-Y. The open-circuit test was performed on the low-voltage side of this transformer bank, and the following data were recorded:

Tiga pengubah pengagih 20kVA 24,000/415-V disambung secara Δ-Y. Ujian litar terbuka telah dilakukan pada bahagian voltan rendah bagi pengubah tersebut dan data berikut telah dicatatkan

Jadual 1
Table 1

Open-circuit test (on secondary side) ***Ujian litar terbuka (pada bahagian sekunder)***	**Short-circuit test (on primary side)** ***Ujian litar pintas (pada bahagian primer)***
$V_{line,OC}$ = 415 V	$V_{line,SC}$ = 1400 V
$I_{line,OC}$ = 4.10 A	$I_{line,SC}$ = 1.8 A
$P_{3\phi,OC}$ = 945 W	$P_{3\phi,SC}$ = 912 W

(i) Find the per-phase values of excitation branch components, its series impedances and draw the per-phase equivalent circuit of this transformer referred to the high-voltage side.

Cari nilai per-fasa bagi komponen cawangan pengujaan, galangan bersiri dan lukiskan litar setara per-fasa bagi pengubah tersebut merujuk pada bahagian voltan tinggi.

(30 marks/*markah*)

(ii) Find the impedances in per-unit value for the per-phase equivalent circuit of this transformer bank.

Cari nilai galangan dalam per-unit bagi litar setara per-fasa pengubah tersebut

(30 marks/*markah*)

(iii) Calculate the full load voltage regulation at 0.8 lagging power factor.

Kira nilai pengaturan voltan beban penuh pada faktor kuasa ekoran 0.8

(20 marks/*markah*)

(iv) Draw the phasor diagram for the voltage regulation obtained in (iii).

Lukis gambarajah pemfasa bagi pengaturan voltan yang diperolehi dalam (iii)

(10 marks/*markah*)

(v) Calculate the efficiency of the transformer at full load with the power factor of 0.8 lagging.

Kira kecekapan pengubah pada beban penuh dengan faktor kuasa ekoran 0.8.

(10 marks/*markah*)

3. (a) State all types of power and loses involved (including the equation) for dc machine operation as in Figure 3.1

Nyatakan semua jenis kuasa dan kehilangan yang terdapat dalam operasi mesin dc seperti di Rajah 3.1

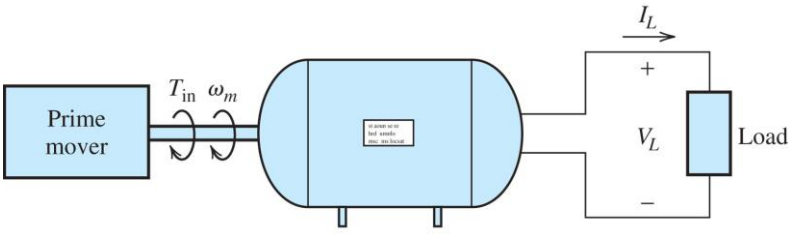

Figure 3.1 DC Machine operation flow

Rajah 3.1 Mesin DC aliran operasi

(30 marks/*markah*)

(b) If the adjustable resistor, R_{adj} for circuit in Figure 3.2 is adjusted to 175Ω, what is the rotational speed of the motor at no-load condition if the magnetization curve is as in Figure 3.3?

Sekiranya perintang boleh ubah, R_{adj} bagi Rajah 3.2 diubah kepada 175W, apakah kelajuan pusingan motor tersebut pada keadaan tanpa beban sekiranya lengkung pemagnetan adalah seperti di Rajah 3.3?

(30 marks/*markah*)

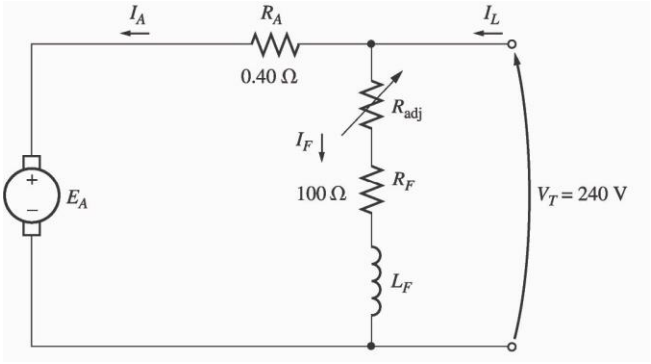

Figure 3.2 Motor equivalent circuit

Rajah 3.2 Litar setara motor

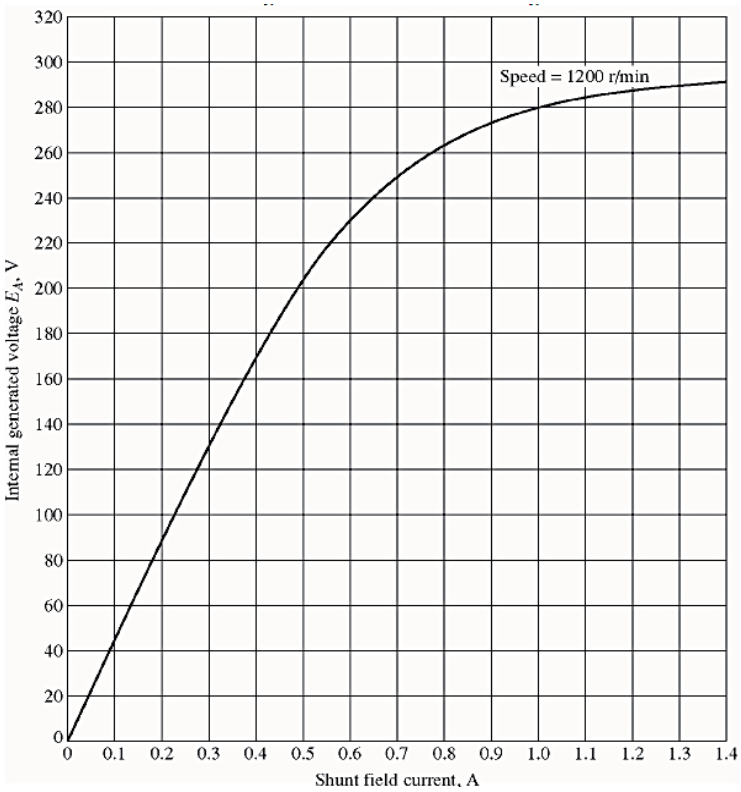

Figure 3.3 Magnetization curve

Rajah 3.3 Lengkung pemagnetan

(c) A 7.5 hp 120 V series dc motor has an armature resistance of 0.2 Ω and a series field resistance of 0.16 Ω. At full load, the current input is 58 A, and the rated speed is 1050 rpm. The core losses are 200 W, and the mechanical losses are 240 W at full load. Assume that the mechanical losses vary as the cube of the speed of the motor and that the core losses are constant, calculate:

Sebuah 7.5 hp 120 V dc motor siri mempunyai rintangan angker 0.2 Ω dan rintangan medan sesiri 0.16 Ω. Pada beban penuh, arus kemasukan ialah 58 A, dan laju terkadar ialah 1050 rpm. Kehilangan teras adalah pada 200 W, dan kehilangan mekanik pada 240 W pada beban penuh. Mengandaikan kehilagan mekanik berubah pada kiub kelajuan motor dan kehilangan teras adalah pemalar, kirakan:

(i) The efficiency of the motor at full load.
Kecekapan motor pada beban penuh.

(ii) The efficiency if the motor operates at the speed of 1326 rpm, I_L = 35 A and E_A = 107.4V.
Nilai kecekapan sekiranya motor beroperasi pada kelajuan 1326 rpm, I_L = 35 A dan E_A = 107.4V.

(40 marks/*markah*)

4. A 415V, 50Hz, Y-connected, four-pole, three-phase synchronous motor has per phase synchronous reactance X_S of 1.5Ω and per phase armature resistance R_A of 0.15Ω. At full-load operation, the armature current I_A is 50A and the power factor is 0.85 lagging. This motor also has friction and windage losses of 1.5kW, and core losses of 1kW at full-load.

Sebuah motor segerak 415V, 50Hz, sambungan-Y, empat-kutub, tiga-fasa mempunyai regangan segerak per fasa X_S sebanyak 1.5Ω dan rintangan angker per fasa R_A sebanyak 0.15Ω. Semasa operasi beban-penuh, arus angker I_A adalah 50A dan faktor kuasa adalah 0.85 mengekor. Motor ini juga mempunyai kehilangan geseran dan angin sebanyak 1.5kW, dan kehilangan teras sebanyak 1kW pada beban-penuh pada 50Hz.

(a) What is the synchronous speed of this motor?

Apakah kelajuan segerak motor ini?

(15 marks/*markah*)

(b) What is the internal voltage E_A during full-load operation?

Apakah voltage dalaman E_A semasa operasi beban-penuh?

(35 marks/*markah*)

(c) Sketch the phasor diagram of this motor.

Lakarkan gambarajah fasa untuk motor ini.

(20 marks/*markah*)

(d) Calculate the efficiency of this motor at full-load.

Kirakan kecekapan motor pada operasi beban-penuh.

(30 marks/*markah*)

5. A 415V, 50Hz, Y-connected, four-pole, three-phase induction motor has the following impedances per phase referred to the stator circuit:

Sebuah motor aruhan 415V, 50Hz, sambungan-Y, empat-kutub, tiga-fasa mempunyai galangan-galangan berikut yang dirujuk kepada litar pemegun:

$R_1 = 0.65\Omega$ $R_2 = 0.35\Omega$ $X_1 = 1.2\Omega$ $X_2 = 0.5\Omega$ $X_M = 30\Omega$

Total rotational losses P_{rot} are 1250W which are assumed to be constant. The core loss is lumped together with the rotational losses. For a slip of 3% at rated voltage and frequency, determine the followings:

Jumlah kehilangan putaran P_{rot} ialah 1250W di mana diandaikan konstan. Kehilangan teras dimasukkan bersama dengan kehilangan putaran. Untuk gelincir pemutar sebanyak 3% pada kadar voltan dan frekuensi, tentukan yang berikut:

(a) motor speed in rpm and in rad/s.

kelajuan motor dalam rpm dan rad/s.

(15 marks/*markah*)

(b) stator current I_1

arus pemegun I_1

(35 marks/*markah*)

(c) total stator copper losses P_{copp} and motor input power P_{in}

jumlah kehilangan tembaga pemegun P_{copp} dan kuasa masukan motor $P_{in.}$

(20 marks/*markah*)

(d) motor output power P_{out}

kuasa keluaran motor P_{out}

(15 marks/*markah*)

(e) motor efficiency.

kecekapan motor.

(15 marks/*markah*)

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